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ABSTRACT

The current paradox between the increasing interest in the utilization of computer-assisted instruction (CAI) and the decreasing financial support from the Federal Government is briefly surveyed in the introduction of this annotated bibliography. The author also discusses the major problems that are now prevalent in CAI utilization: the lack of specialized programing and the scarcity of research based knowledge. An annotated bibliography of some 40 recent articles is divided into the categories of CAI planning and utilization, case studies of utilization, attitudes toward CAI, cost effectiveness studies, research trends in student-CAI interaction, and the future prospects and policies. (MC)

An ERIC Paper

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The Best of ERIC:

RECENT TRENDS IN COMPUTER ASSISTED INSTRUCTION

By Dr. Richard E. Clark
Director, ERIC Clearinghouse
on Media and Technology

April 1973

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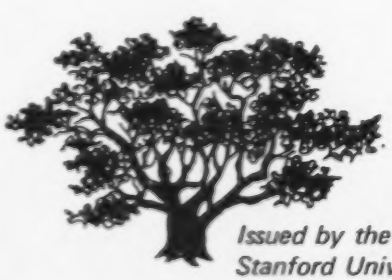

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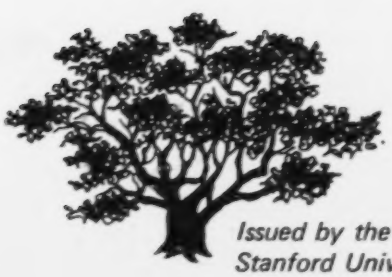

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INTRODUCTION

At the present time computer assisted instruction (CAI) is faced with a curious paradox; interest in CAI utilization is increasing at the school district and classroom level in education while financial support from the Federal Government for research, demonstration and utilization projects is decreasing.

Federal Support

A recent review of Office of Education (OE) CAI projects by Grayson and Robbins* (1972) illustrates a dramatic decline in OE yearly support for CAI, even though more than $110 million was spent on CAI school programs between 1966 and 1971. Disenchantment at the Federal level may be temporary. The newly created National Institute of Education (NIE) is expected to absorb most of the CAI projects originally managed by OE. There is some feeling in NIE that the OE projects did not pay off as much as expected, i.e. too much emphasis was placed on demonstration projects and hardware development while evaluation, research and software development were neglected. NIE is now in the process of studying problems and reformulating policy for the entire area of educational technology including CAI. In many other federal agencies the current emphasis is on support for projects which develop and test software. Attention is also being given to problems involved in cataloging and disseminating software already available from government sponsored projects.

It is safe to suggest that in the next five years local CAI projects will not enjoy the same level of financial support from the Federal Government received in the previous five years. The current transitional period in government policy toward CAI may be due as much to limited funds as to any major problems associated with our previous experience with using computers in instruction.

CAI in the Classroom

Local interest in CAI is partially due to the success of federally sponsored programs in demonstrating that CAI is feasible and, under certain circumstances, cost effective. Many school districts have now had a chance to either use or observe the operation of successful CAI projects. Fears that CAI would dehumanize instruction have been softened by recent evidence (e.g. Gipson, 1971 – page 6 in this review) that many students, especially the disadvantaged, view the experience as an exceptionally equitable form of instruction.

Teachers are less reluctant to involve themselves in CAI programs because experience has suggested that classroom computer applications will not work without their active and knowledgeable participation (see e.g. Burrows, 1970, page 6 in this review).

Major Problems in CAI Use

The most serious problems confronting those who wish to use computerized instruction in schools are the lack of specialized programming and scarcity of research-based knowledge which will contribute to effective utilization. The first problem might be partially solved by a thorough examination of computer programs and curriculum which have been developed in previous government projects and which are available to local school districts at a minimum cost. Sections One (Planning and Utilization) and Two (Case Studies) are included in this review of trends as examples of the types of information about such programs available from the ERIC system.

The second difficulty, a lack of sufficient research in the area, is more acute. Section Five (Research Trends) – especially the article by Mitzel, 1969, page 7 – describes a line of inquiry which shows great promise. The huge storage capacity of most computer systems makes it possible to design individualized instruction which is based on the unique abilities, aptitudes, traits, and preferences of each student. Theoretically, futuristic computer instruction could provide each student client with a "specially tailored" lesson. Another benefit of this line of inquiry is advance knowledge for educational administrators of what it costs to teach students whose abilities are known.

Additional sections of the review deal with research evidence on attitudes (Section Three), examples of studies which examine the various cost factors which should be considered in employing CAI in schools (Section Four), and papers which have examined future prospects and policy considerations (Section Six).

Speculation About the Future of CAI

Though one should be wary of suggesting that anything in education is inevitable, computerized instruction seems destined to become the most important technological device for the shaping and delivery of instruction.

As the mechanical sophistication of computer generated graphics and audio increases and costs decrease, the computer might be expected to effectively replace the technology currently associated with media such as movies, television, still photographs, line drawings, and so on. The hardware to make these innovations possible is being developed in industry. It would be more comforting if our confidence in the steady growth of the technology of CAI could be matched with assurances that we will generate sufficient research and experiential knowledge about how and what students learn from computerized instruction.

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*Grayson, L. P. and J. B. Robbins, U.S. Office of Education Support of Computer Activities: 1965-1971, Report No. OE 12044-71. U.S. Government Printing Office, April 1972. See also: Grayson, L. P., "The U.S. Office of Education and Computer Activities: A summary of support," *Educational Technology, 11* (11), November, 1971, pages 51-54.

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CAI PLANNING AND UTILIZATION

How have others used computer assisted instruction?
What computer programs are available to implement CAI in local school districts?
What factors should be considered in planning CAI use?

Computer Literature Bibliography 1946 to 1963.

W. W. Youden, National Bureau of Standards, Department of Commerce, Washington, D.C., Institute for Applied Technology, 1965, 463 pages. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 as document 1966-O-796-980 for $3.75.

Over 6,100 references are contained in this bibliography of computer literature published from 1946 to 1963. The full titles and all of the authors of every article published in 9 journals, 21 books, and over 100 proceedings are included. The books selected are those that have chapters by individual authors, as such chapters are not normally indexed in most libraries. Articles are listed under the publication in which they appeared. The title of the publication, the publisher, year of publication, and the Library of Congress classification and catalog card number are given. For proceedings, the location and date of the meeting is noted. A key-word-in-context index can be used to find an article if any part of its title is known or to find all articles whose titles include a particular word or phrase. An author index lists all authors of each article, but does not indicate whether an individual is the sole author of the article.

Computer Literature Bibliography; Volume 2, 1964-1967.

W. W. Youden, National Bureau of Standards, Department of Commerce, Washington, D.C., Institute for Applied Technology, 1968, 381 pages. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. as document 1968-O-322-559 for $5.

In this second volume of a two-volume bibliography of computer literature, approximately 5,200 references from 1964 to 1967 are listed. The full titles and the names of all the authors of articles published in 17 journals, 20 books, and 43 conference proceedings are given. In addition, references to all items that were reviewed in the Institute of Electrical and Electronics Engineers (IEEE) Transactions on Electronic Computers have been included. Publications are listed in alphabetical order by an assigned acronym. Within each acronym, the references are listed in year, issue number, and page number sequence. For each publication the bibliography gives the title, name of publisher, year of publication, Library of Congress classification and catalog card number, and, for proceedings, the location and date of the meeting. A key-word-in-context index provides a means of locating an item if any part of its title is known. An author index lists all authors of each item, but does not indicate whether an individual is its sole author.

CAI Systems Past, Present, and Future.

Samuel L. Feingold, System Development Corporation, Santa Monica, California, 1970, 9 pages. Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151 as document AD-702 686 for 95c in microfiche and $3 in Xerox hardcopy.

In considering the development of computer-assisted instruction (CAI) systems over the past eleven years, one can see a pattern of interaction between advances in computer hardware and software and continuing efforts to solve the basic problems of CAI: problems of achieving a natural-language capability, of keeping the cost low, and of making coding and editing easier. As new equipment and the higher level languages became available, solutions to one or another of these basic problems have become feasible. Now, in the fourth generation of CAI, we have on line, time-sharing capabilities and a powerful and flexible language that embodies both program logic and instructional content. This pattern gives some hint of how things will proceed in the future: through a continuing iteration between technology—in the forms of the mini-computer on the one hand and the extremely large time-share facility on the other—and further efforts to solve the more complicated needs that face us now.

Teacher Control in Computer Assisted Instruction. ED 066 027.

Peter Calingaert, 1972, 23 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Systems of computer-assisted instruction (CAI) can be classified according to whether the author, student, or teacher controls the interaction between the student and the computer. Both author-controlled and student-controlled CAI have the advantages of individualized instruction, privacy for mistakes, and flexibility, but are tremendously expensive. Student-controlled CAI further allows a student to be much more active, but also makes supervision difficult. A teacher-controlled system used as another teaching tool before a whole class of students is much cheaper than the other types of CAI, and adds to the computer program an intelligent subsystem, the teacher, to filter input and modi-

fy the stream of presentation. Teacher-controlled CAI gives up the advantages of individual attention, privacy and flexibility, but the criterion of cost-effectiveness makes it an attractive possibility in the hands of a skillful teacher.

A Program to Teach Programming.

Robert R. Fenichel and others, Massachusetts Institute of Technology, Cambridge, 1969, 6 pages. Available from the National Technical Information Service, Springfield, Virginia 22151 as document AD-706 268 for 95c in microfiche and $3 in Xerox hardcopy.

The TEACH system was developed to provide inexpensive, effective, virtually instructorless instruction in programing. The TEACH system employed an interactive language, UNCL. Two full sections of the TEACH course were taught. The results of this experience suggested ways in which the research and development effort on the system should be continued and provided information for evaluating the effectiveness of the course. Pedagogically, the system appears to be successful; straightforward reimplementation should make it economically successful as well. An appendix contains a complete description of the UNCL interpreter.

Teacher-Student Authored CAI Using the NEWBASIC/CATALYST System. ED 043 235.

T. A. Dwyer, Pittsburgh University, Pennsylvania, 1970, 21 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Using an interactive computer system called NEWBASIC/CATALYST, both students and teachers can act as authors of programs. NEWBASIC/CATALYST incorporates an implementation of BASIC, system-level interactive features, and a general capability for extension through use-oriented function attachment. Interacting at the system level, students can mix the advantages of independent or "solo" mode computing with those of guided or "dual" mode interaction. Illustrations of this are given. Preliminary experience with the system was in an urban secondary school setting.

DISCUS Interactive System Users' Manual. Final Report. ED 060 919.

Steven S. Silver and Joseph C. Meredith, University of California at Berkeley, Institute of Library Research, 1971, 173 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

The results of the second 18 months (December 15, 1968-June 30, 1970) of effort toward developing an Information Processing Laboratory for research and education in library science is reported in six volumes. This volume contains: the basic on-line interchange, DISCUS operations, programming in DISCUS, concise DISCUS specifications, system author mode, and exercises. DISCUS is an interpretive man-computer interface system. The six parts of this manual contain: (1) an introduction to the general idea of computer assisted instruction, (2) an explanation of the several DISCUS statements, (3) a discussion of the role of the programmer vis-a-vis the author/instructor, (4) definitions and specifications, (5) a description of the program debugging facilities provided by the DISCUS language and (6) six series of exercises supplementing Parts II and III. Other volumes of this report are available as ED 060 916, ED 060 917, ED 060 918 and ED 060 920.

Computer Terminal Selection: Some Instructional and Psychological Implications. ED 054 651.

Bobby R. Brown and Harold F. O'Neil, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1971, 29 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Factors which have previously provided the basis for decisions as to the use of CRT (cathode ray tube) of teletype terminals in computer-assisted instruction (CAI) may be decreasing in importance. Specifically, differential cost factors and teleprocessing capability may no longer provide a basis for differentiating between CRTs and teletypes. In this paper several experiments are reviewed, and the instructional and psychological implications of instructional terminals are discussed. The major terminal characteristics discussed are cost, teleprocessing capability, presentation rate, and display mode. The major instructional and psychological implications discussed are device memory load factors and instructional time and efficiency. Student characteristics of intelligence and anxiety are discussed in relation to instructional terminal characteristics.

Measurement Techniques for Individualized Instruction in CAI. ED 053 550.

Duncan N. Hansen and Barbara F. Johnson, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1971, 28 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Individualized instruction presents problems in measurement which challenge the conventional measurement paradigms. Measurement techniques must take into consideration the problems of item variance characteristics of computer-assisted instruction (CAI), idiosyncratic learning sequences, and lack of a model for effectiveness assessment. The strategies used at the Florida State University CAI Center focus on two major goals: measurement to provide information on priorities for revision within the CAI course materials and measurement to increase the effectiveness of the instructional process. Measurement techniques which are suited to evaluate three levels of course characteristics—microframe, concept segments within a CAI course and effectiveness models—are described and foreseeable future trends are briefly discussed.

CASE STUDIES

How has CAI been used at different levels of education?
What utilization and planning suggestions are made by teachers and administrators who have had direct experience with CAI?

Elementary Education

Model Programs: Childhood Education. A Computer-Assisted Language Experience Which Allows Children to Create Their Own Reading Lessons. ED 044 932.

American Institutes for Research in the Behavioral Sciences, Palo Alto, California, 1970, 24 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

One hundred black children in two all-black elementary schools in rural Florida were taught reading by a method described as Differentiated, Oral, Visual, Aural, Computer-ized, Kinesthetic (DOVACK). The children dictated their own stories in their own Afro-American dialect on dictaphone belts. A computer furnished printouts of the stories for the children to read. They could also hear their own words played back on recordings made by the teacher. Each new word a student used was recorded by the computer; thus a running record of a child's vocabulary development was created. Reading progress was achieved by introducing students to standard English usage through composite stories. These were standard English versions of the pupil's own dictation and gave him a chance to recognize his own words and thoughts in a different context. Periodic tests were given to evaluate the students' progress and needs. The computer printed out a weekly pupil progress report which the teacher used to prescribe corrective steps. Present cost per student for the DOVACK approach is $770 above the regular district expenditure of $658. Parent support for the program is very good; and parents of children not in the program are asking for an expansion of the program to include all the children.

A Computer-Based Instructional Management Program for Classroom Use. ED 052 621.

Richard E. Sass, Pittsburgh University, Pennsylvania, Learning Research and Development Center, 1971, 76 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

An instructional management program was developed to assist students in selecting learning activities. The program was based on a general model for specifying hierarchical curriculum structure. This model was developed using the directed graph, a mathematical form of a structural model. A hierarchy could then be generated from the curriculum designer's responses about the prerequisite relationships among the lessons in his curriculum. Using a student mastery data base, programs were designed to input data on a student's mastery of lessons, list data, and output options for learning activities for students. The program to provide options eliminated lessons which students had already mastered and printed out an option only if all its prerequisites had been mastered. Also, feedback about activities chosen was returned to the designer. Flowcharts for these programs are included. Field tests of the programs in a first-grade science class led to the conclusion that its future application requires mature students, a relatively free instructional setting, a quick and reliable computer system, outside financing, close ties to classroom management, and a structured curriculum based on well defined objectives.

INDICOM. (Individual Communications System). Final Report. ED 061 707.

Waterford Township School District, Pontiac, Michigan, 1970, 100 pages. EDRS price microfiche 65c, hardcopy $3.29.

The Individual Communications System (INDICOM) was begun in 1967 in Waterford School District, Michigan, as one of the first public school computer-assisted instruction projects in the Midwest. Its specific aim in developing CAI was to fuse the latest technology with the best thinking in education so as to create an instructional system which would allow each student to enter at his own level and to proceed at his own pace. This document serves as a yearbook and complete description of the program and its personnel. INDICOM's directors maintained the thesis that instructional innovation must begin with the teachers (who were trained in CAI program design) or it will end outside the classroom door. Full description of the development of all aspects of the program is given. The feeling is expressed throughout that INDICOM's experience has been a great success and that it documents the potential of computer instruction in individualizing teaching and in solving the problems of U.S. public education.

Secondary Education

A Commonwealth Consortium to Develop, Implement and Evaluate a Pilot Program of Computer-Assisted Instruction for Urban High Schools. Final Report. ED 059 604.

Harold E. Mitzel and others, Pittsburgh University, Pennsylvania, School of Education, 1971, 213 pages. EDRS price microfiche 65c, Xerox hardcopy $9.87.

The school districts of Pittsburgh and Philadelphia, the Department of Education of the Commonwealth of Pennsylvania, and Pennsylvania State University formed the Computer-Assisted Instruction Consortium to develop and evaluate two high school mathematics programs utilizing the medium of computer-assisted instruction. The first 18 months of the project (until fall of 1969) were spent in curriculum development activities. A full-year trial of the materials provided feedback for course revision and blocking of exercises into units. During the school year 1970-71 the Consortium worked on a major evaluation effort, dissemination activities, and polishing the curriculum materials in general mathematics and algebra. The predominant theme for the curriculum was teacher-

monitored independent study for each student. Two main types of material composed the individual study curriculum: an "on-line" or computer-mediated component involving student/content interaction at the computer terminal and an "off-line" component consisting of self-study in a variety of modes, such as workbooks, filmstrips, puzzles, games, and textbooks. Both the general mathematics and the algebra material were designed to appeal to urban youth. The course development, summative evaluation, and a cost analysis of the system are presented along with summaries of the courses and the materials prepared for them.

On the Importance of Complexity in Supportive Systems for Educational Computing. ED 053 565.

Thomas A. Dwyer, 1970, 8 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

To help investigators become more aware of hidden limitations in their work, some important supportive systems to the application of interactive computing in education are described. Support systems are grouped under the headings of technical support, pedagogical and logistical support, and administrative support and are further illustrated by examples under each heading: Technical support includes system-level software, language-level software, and research and development; pedagogical and logistical support is divided into curriculum material support, scheduling, and critical size; and administrative support covers teacher training, public relations, and economics. Within each example, three levels of complexity are given to alert educators to the fact that they are dealing with a variety of constraints and to recommend that they take this into account in their planning and ultimate evaluation. The author draws on his experience with Project Solo, a program concerned with the use of interactive computing within conventional secondary schools, to point out that systems of inadequate complexity can interact on a total effort in a negative, but often hidden manner.

See also: Teacher-Student Authored CAI.... page 3.

Community College and University

Research and Implementation of Collegiate Instruction of Physics Via Computer-Assisted Instruction. Volume I. Final Report. ED 059 609.

Duncan N. Hansen and others, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1968, 150 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

A large scale investigation into the development and effectiveness of a collegiate level computer-assisted instruction (CAI) course in undergraduate physics is reported. The work, which began in 1966, involved a full commitment to investigate all phases of the development, execution, revision, and cost-effectiveness of a CAI physics course from a research point of view. This volume of the study covers the topics of: 1) the statement of problems, 2) the background literature, 3) the developmental curriculum processes, 4) a description of the multimedia techniques used within the course, 5) a set of CAI physics problem exercises, and 6) the three subsequent field studies. It concludes with a presentation on cost analysis and a summary of important conclusions. Volume 2 of the study (ED 059 610) presents the appendices that describe in complete detail the nature of the learning material and evaluative instruments utilized. Volume 3 (ED 059 611) is a presentation of the CAI curriculum.

Computer Assisted Instruction of College Physics Students in Small Groups. Final Report. ED 064 952.

Glen E. Gerrell, 1972, 49 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

An experiment was performed in a two semester introductory college physics course for non-science majors. The goal of the experiment was to determine the extent to which computer-assisted instruction (CAI) and knowledge of group dynamics can overcome the serious instructional problems of large introductory lecture courses. Students were divided into three sections. Students in one section received the CAI as individual students; students in another section studied in small groups and received the CAI as a group; the third section served as a control group. Academic achievement, attitudinal development, and the sociometry of the students in the test sections were studied. It was found that the students preferred small group instruction. The students studying in small groups sometimes achieved academic results which were superior to the control group; but occasionally the small group produced significantly inferior results. When this happened, the group also demonstrated a significant deterioration in social structure. The small group instruction had a much lower cost per pupil than did the individual use of CAI. It was therefore concluded that a combination of CAI and careful attention to group dynamics may be an effective and economical way to solve the problem of large group instruction in introductory college courses.

See also: Justifying CAI in Mainline Instruction.... page 6.
Systems Concepts and Computer-Managed Instruction.... page 7.
Anxiety, Drive Theory.... page 8.
Computers in Instruction: Their Future... page 9.

ATTITUDES TOWARD CAI–STUDENTS, TEACHERS AND SCHOOL ADMINISTRATORS

How do the attitudes of students, teachers and administrators toward CAI influence success?

Use of Computer Assisted Instruction for Teaching Mathematics to the Disadvantaged. ED 051 672.

Joella Gipson, 1971, 23 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

The instructional needs of culturally disadvantaged students must be differentiated from the needs of slow learners

and from the needs of mentally retarded children. The characteristics of a disadvantaged student's family structure, home environment, and neighborhood all affect his learning potential. The special needs of disadvantaged students suggest that, particularly in the field of mathematics instruction, modern electronic technology will be helpful. Computers may be especially useful in that they allow the program of instruction to be individualized to suit the student's needs. Experience with computer-assisted instruction (CAI) drill-and-practice programs such as those developed by the Institute for Mathematical Studies in Social Science, by the IBM Watson Research Center, and by RCA indicates that improvements in performance and student and teacher attitudes may be expected when CAI is used with disadvantaged students. CAI can be useful in overcoming negative teacher attitudes toward disadvantaged students, in teaching students to follow instructions, and in stimulating student interest. CAI would seem to be an important tool to be used to overcome learning problems created by a deprived environment. A table listing CAI programs for the disadvantaged is provided.

Coast's Practitioners Review Computer Assisted Instruction. ED 060 847.

Richard W. Brightman, Coast Community College, Costa Mesa, California, 1972, 31 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

A review of the literature concerning computer assisted instruction (CAI) yielded 23 assertions of the value of CAI as an instructional technique. Sixty-seven faculty members in two community colleges who have had opportunities to use CAI were surveyed as to their agreement or disagreement with each assertion. The faculty responses showed widespread agreement with all 23 assertions with a few differences of opinion appearing between faculty members teaching technical and those teaching non-technical subjects. Comments made by the respondents suggest a need for data file access for CAI purposes and that alternative instructional systems may be more effective than CAI in realizing some of the assertions. The author recommends that considerably more research is needed to compare the relative costs of CAI and to assess whether or not its increased effectiveness, if any, is justified.

Persistent Problems in System Development. ED 046 436.

J. H. Burrows, Mitre Corporation, Bedford, Massachusetts, 1970, 48 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Technological innovation in the form of the introduction of a formal information system represents change to the people within the organization. This paper (presented to California Educational Administrators participating in the Executive Information Systems program of Operation PEP—Prepare Educational Planners) is directed to those managers who initiate the introduction of a new system and are responsible for the successful assimilation of it into their organization. Such a change presents problems, which if not approached correctly, can negate any anticipated benefits. Problems of organization involve the top management, middle managers and the bottom of the organizational structure. As institutors of a new information system, the top-level managers must be certain that those below them feel and derive benefits as active participants in the system design, development and use. Problems of change and growth encompass: (1) changes in information flow and availability, (2) personnel growth, (3) applications, (4) cost, and (5) new employees. The problems resulting from the consideration of standards versus adaptability when contemplating a new information system must be settled by top management in light of the particular needs of their organization so that it will be flexible and workable.

The Computer as a Socializing Agent; Some Socioaffective Outcomes of CAI. ED 044 942.

Robert D. Hess and others, Stanford Center for Research and Development in Teaching, Stanford University, 1970, 141 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

The socializing role of computer-assisted instruction (CAI) was seen to be a positive one in this study. The students, predominantly Mexican-American, who experienced CAI, and other students, in a control group, who did not, liked the computer. They thought it gave the right answers and they respected it as having a vast array of information available to it. They also saw it as fair, trusted its evaluations as well as its handling of task assignments, and sometimes attributed to it an almost human role. Feelings of greater trust in the learning situation managed via computer as compared to a learning situation monitored by a teacher were especially evident among CAI students. On the other hand, while both groups tended to ascribe charismatic qualities to the computer rather than to the teacher, CAI students were more aware than their Non-CAI peers of the computer's unresponsiveness to students' eventual desires to change the course or the content of its lessons. Greater confidence in the computer as compared to the teacher may follow from the fact that the teacher is perceived as evaluating student performance in mathematics tasks on the basis of behavior not related to these tasks.

See also: Anxiety, Drive Theory.... page 8.

COST EFFECTIVENESS STUDIES

What does CAI cost?

Justifying CAI in Mainline Instruction. ED 052 601.

Victor C. Bunderson, Texas University, Austin, Computer-Assisted Instruction Lab, 1970, 29 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Costs and production requirements for developing "mainline," as distinguished from "adjunct" computer-assisted instruction (CAI), are discussed. "Mainline" programs are

complete systems which teach an entire course, while "adjunct" programs supplement a regular course. Mainline CAI programs are expensive. A course equivalent to a three-credit semester course usually takes a year to write and another year to evaluate. Present costs range from at least $5,000 to $10,000 per student hour, and at best, they might be reduced to $3,000 an hour assuming the existence of languages, systems, and authoring techniques which are still under development. However, one possible individualized instruction environment which could accommodate the logistics of CAI is described and illustrated. It makes extensive use of program design and supplementary help by teaching assistants. This model, which uses as an example a course in college freshman mathematics, has been shown to be reasonably effective and to be more economical than traditional instruction.

Systems Concepts and Computer-Managed Instruction: An Implementation and Validation Study. ED 050 543.

Walter Dick and Paul Gallagher, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1971, 27 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

The Florida State model of computer-managed instruction (CMI) differs from other such models in that it assumes a student will achieve his maximum performance level by interacting directly with the computer in order to evaluate his learning experience. In this system the computer plays the role of real-time diagnostician and prescriber for the student and serves as a master record-keeper for the entire student population. To test this model of CMI, systems concepts were used in developing a programed course to teach graduate education students the techniques of programed instruction. In a field trial of the course, four instructional presentations were used: students followed a fixed sequence of tasks and had a graduate student evaluate their progress, students selected their own sequence of tasks and had a graduate student evaluate their progress, students followed a fixed sequence and evaluated their progress with the aid of a computer, and students selected their own sequence and evaluated their progress with the aid of a computer. No significant differences were found among the experimental treatment groups. Student performance on the cognitive portion of the course was excellent, and it was estimated that the cost of conducting the course via CMI was one-half to one-third the cost of conventional graduate instruction.

See also: Media Programs: Childhood Education.... page 4.
A Commonwealth Consortium.... page 4.
Research and Implementation of Collegiate Instruction.... page 5.
Computer Assisted Instruction of College Physics.... page 5.
Coast's Practitioners.... page 6.
Educational Production Functions.... page 9.
The New Instructional Technologies.... page 9.
Educational Computer Utilization.... page 9.

RESEARCH TRENDS: INTERACTIONS BETWEEN STUDENT CHARACTERISTICS AND VARIETIES OF CAI

What emphasis should be placed on CAI research?
Which of the possible research directions provides the greatest payoff?
What does "individualized instruction" imply for the researcher?
What information is available from previous research which will make CAI planning and utilization more effective?

The Impending Instructional Revolution. ED 036 462.

Harold E. Mitzel, 1969, 20 pages. Speech presented at the 77th Meeting of the American Society for Engineering Education, University Park, Pennsylvania. EDRS price microfiche 65c, Xerox hardcopy $3.29.

The last three decades of the twentieth century will witness a drastic change in the business of providing instruction in schools and colleges. The idea of "individualized instruction" has been pursued in a desultory fashion by American educators for most of the century. There have been several different concepts of individualization, the most prevalent interpretation focusing on self-pacing or rate-tailoring. The impending instruction revolution will shortly bypass the simplex idea of individualizing instruction and move ahead to the more sophisticated notion of providing "adaptive instruction" for school and college learners, with focus on the tailoring of subject matter presentations to fit the special requirements and capabilities of each learner. Essential to the idea of adaptive education is the means of utilizing new knowledge about individual differences among learners to bring a highly tailored instructional product to the student via computer-assisted instruction in which many identifiable learner variables are taken into account. Two concomitants to the revolution which seriously concern college faculty and administrators are adaptation to increased heterogeneity in mental ability and school preparation among college students and a drastic revision in the approach to learner evaluation and grading practices. Student evaluation would be based on the concept that an achievable mastery criterion exists for each course.

An Investigation into the Differential Effectiveness for Males and Females of Three CAI Treatments on Delayed Retention of Mathematics Concepts. ED 034 426.

Lorraine R. Gay, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1969, 49 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

A study was developed to evaluate the effectiveness of a preinstruction retention index (designed to maximize recall of mathematical concepts by predicting the idiosyncratic number of examples per mathematical concept required by each student). Subjects, 27 female and 26 male eighth grade students, were administered a retention measure through computer-assisted instruction (CAI) and randomly assigned to one of three treatment groups, each providing similar CAI mathematical concepts and different methods of determining the number of examples per concept provided (variable, choice, or fixed). A two-way analysis of variance, with sex and treatment group as the independent variables, was performed; results showed that females in the "variable" group performed significantly better on retention measures than did females in "choice" or "fixed" groups, and that males in the "choice" group performed better on retention measures than did males in the other two groups. In addition, it was found that the use of the preinstruction index resulted in overall better retention for females but not for males, indicating the possible usefulness of such an index in mathematics instruction and a need for further research into the sex variable in retention.

Anxiety, Drive Theory, and Computer-Assisted Learning.

Charles D. Spielberger and others, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1970, 67 pages. Available from the National Technical Information Service, Springfield, Virginia 22151 as Document AD-714 504 for 95c in microfiche and $3 in Xerox hardcopy.

Hypotheses about the effects of anxiety on performance in computer-assisted instruction (CAI) were formulated and then tested. High school students and college students were used in the experiments. Learning materials were in the subjects of science, mathematics, psychology, physics, and educational research. Two settings were compared: a laboratory setting and a computer-assisted instruction setting. An IBM 1500 CAI system was used in the experimentation. The findings supported the Trait-State Anxiety Theory in the prediction that HA (High Anxiety)-Trait subjects will show greater evaluations in A(Anxiety)-State than LA (Low Anxiety)-Trait subjects in learning situations in which the subject's personal adequacy is evaluated, or which pose a threat to self-esteem. The findings were also interpreted as generally consistent with the Spence-Taylor Drive Theory, although certain results suggested that the effects of anxiety on learning may not be the same for men and women. It was concluded that investigators should evaluate sex differences in research on anxiety and learning. References are given.

An Investigation of Instructional Treatments and Learner Characteristics in a Computer-Managed Instruction Course. Tech Report Number 12. ED 042 360.

Paul D. Gallagher, Florida State University, Tallahassee, Computer-Assisted Instruction Center, 1970, 112 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

The intent of this investigation was to answer a number of questions in regard to instructional treatments and learner characteristics in a Computer-Managed Instruction (CMI) learning environment. Treatments varied in terms of sequence of tasks and evaluation of instructional materials. Sequencing was either student-selected or computer-assigned while evaluation was conducted by an instructor or by means of a student-computer interaction. Analyses were conducted to identify specific student attitudes, personality characteristics, and background information related to course success. There were no differences among the four instructional treatments on any of the four dependent measures: midterm score, final product score, time to complete the course, and system time. Further analysis indicated that there was a relationship between specific learner characteristics and course success. The students who proved most successful in the course indicated that they liked to be active in the learning situation, admitted to few feelings of anxiety, and expressed positive attitudes toward CMI. A relationship also was found between on-task anxiety state and performance on task quizzes. This investigation is thought to have laid the groundwork for future research in the area of CMI.

Research Program on Cognitive Abilities and Learning. Final Report. ED 051 669.

C. V. Bunderson and J. L. Dunham, Texas University, Austin, Computer-Assisted Instruction Lab, 1970, 57 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

The major results and conclusions of a program of research concerned primarily with the relationship of cognitive abilities to learning are summarized. The major purpose of this research was to develop theorems of instruction related to the interaction of task variables and individual difference variables and to develop them in a manner relevant to the instructional designer's task. The studies focused on the relationship of cognitive abilities to the learning of concepts and rules and to the learning of an imaginary science of "Xenograde systems." The goal was to establish a theoretical and methodological continuum from simple concept learning, through the learning of a complex system of concepts and rules, to a set of instructional design procedures which permit transfer of this knowledge into practice. On the basis of the studies a model for research in this area was recommended, cognitive processes relevant for concept and rule learning were defined, and a hypothesis construction model of simple concept learning was outlined, along with proposed theoretical considerations for more complex concept learning and specific recommendations for instructional design utilizing differences in intellectual abilities.

A Course of Study and Bibliography for Instruction in Educational Media Research and Theory. Final Report. ED 031 950.

William H. Allen, 1969, 170 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

Organization of this graduate course of study in educational media research and theory consists primarily of developing a course outline, providing a single objective and some teaching suggestions and approaches for each unit, and gathering an extensive bibliography (with specific reference to the most recent and the most useful sources). Unit 1 presents an overview of the literature. Unit 2 considers the psychology of learning, perception, physiology, and communication process and information theory. Unit 3, Media Characteristics and Effects, studies the specific characteristics that different media hold jointly or uniquely. The fourth unit, Message Design and Production, deals with preproduction testing and evaluation, motion and audio relevance, repetition, active student response, directed attention and response guidance, and technical production factors. The fifth unit, titled Media Relationships to Instructional Objectives and Subject Matter, and the sixth unit, Media Relationships to Learner Characteristics, indicate directions for much needed research. The final unit, Conditions of Instructional Media Use, applies educational media to practical situations. Class development of a synthesis and taxonomy is encouraged.

See also: Computer Terminal Selection.... page 3.
Measurement Techniques for Individualized

Instruction.... page 3.
Computer Assisted Instruction of College Physics.... page 5.
Use of Computer Assisted Instruction for Teaching Mathematics.... page 6.

FUTURE PROSPECTS AND POLICY

Where does CAI go from here?
What types of policy decisions are most crucial for effective CAI development?

Computers in Instruction: Their Future for Higher Education. ED 052 635.

Roger E. Levien, editor, Rand Corporation, Santa Monica, California, 1971, 225 pages. Proceedings of a conference on Computers in Instruction: Their Future for Higher Education, Santa Monica, October, 1970. EDRS price microfiche 65c, Xerox hardcopy not available from EDRS. Also available from Communications Department, The Rand Corporation, 1700 Main Street, Santa Monica, California 90406 for $5.

The goal of this conference was not exchange of information, but rather, identification of the decisions that should be made by higher education, industry, and government to facilitate the valid growth of the instructional use of the computer. Four major questions concerned the conferees: What will be the computer's capabilities and cost? How will computer services be provided to the campus? How will instructional materials be provided? and How will higher education be affected by instructional computer use? The reports of the conference sessions are divided into three sections; first, discussions of the range of possible answers to the major questions; second, reports on the recommendations developed by the several studies of instructional computer use that are currently under way or have been recently completed; and third, specific recommendations for higher education, industry, and government.

Educational Production Functions for Teacher-Technology Mixes: Problems and Possibilities. ED 064 900.

Barry D. Anderson and Edward Greenberg, Washington University, St. Louis, Missouri, Program on Application of Communication Satellites to Educational Development, 1972, 104 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

The use of large-scale delivery systems to transmit information and skills to a large number of users at low cost is examined. A systematic review of past and current experiments with educational applications of computers and television is coupled with a study of the social milieu in whichpublic schools can be expected to operate in the near future. The paper is divided into four sections: a general overview of the social conditions which characterize schools today, an overview of the many studies which have been done in the use of television and computers in education, and economic analysis of some of the best studies of media use in order to provide some data about the combinations of media and teacher which could produce a given "educational outcome"; and a summary of findings and implications. The report notes that while it is well established that students can learn from both television and computers, studies have not been done with an eye toward an economic product approach which would allow the determination of the best media-teacher mix to produce a given educational outcome. It is also found that certain aspects of the social milieu of present day education work against the effective use of educational technology.

The New Instructional Technologies: Are They Worth It? ED 058 498.

Sidney G. Tickton and Sherwood Davidson Kohn, Academy for Educational Development, Inc., Washington, D.C., 1971, 110 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

Two authors discuss educational technology innovations, costs, and effectiveness. Sidney Tickton summarizes the CIT report of 1969-70 and new data highlights from the present study. He recommends that government agency sponsors of technology projects demand cost and result information and comparative studies with other systems presenting identical offerings. Sherwood Kohn sets forth the study objectives: (1) probe further into educational technology cost, and (2) attempt to assess potential benefits and costs of educational technology innovations. Mr. Kohn relates that the costs of educational TV, computer teaching techniques, and audiovisual aids were reviewed; the results of technological innovation in "controlled" environments and in disadvantaged and experimental schools examined; and the effect of new educational tools and techniques on productivity determined. Data were gathered from consultations with over 50 authorities; polls of 90 educational TV stations and 50 State education departments; searches at ERIC centers for new reports on instructional technology; and from analysis of reports published by local school units. Data revealed that TV and computers, because of their cost effectiveness promise, are being accepted as teaching tools in crucial areas, and that there exists a deeper understanding and a greater use of technology by educators with a corresponding change in emphasis from teaching to learning and from mass to individual instruction. For a related document, see ED 058 473.

Educational Computer Utilization and Computer Communications. ED 057 575.

Jai P. Singh and Robert P. Morgan, Washington University, St. Louis, Missouri, 1971, 101 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

As part of an analysis of educational needs and telecommunications requirements for future educational satellite systems, three studies were carried out. 1) The role of the computer in education was examined and both current status and future requirements were analyzed. Trade-offs

between remote time sharing and remote batch process were explored as were trade-offs between on-campus minicomputers and shared centralized facilities. 2) An analysis was made of the various aspects of computer communications including the nature of communication terminals and the facilities for data-communications. 3) The use of communications satellites was examined for providing telecommunications for computer applications, with the emphasis on high-powered satellite systems involving small, interactive earth-terminals. The report concludes that what is needed to satisfy computing requirements is relatively high-power dedicated educational satellites capable of operation with a large number of small earth terminals. Although such a development would require a pooling of a large percentage of educational telecommunications users, the economies of such a system appear to be attractive compared to terrestrial-based communications for distances greater than 70 miles.

Factors Inhibiting the Use of Computers in Instruction. ED 069 219.

Ernest J. Anastasio and Judith S. Morgan, Interuniversity Communications Council, Bethesda, Maryland, 1972, 130 pages. EDRS price microfiche 65c, Xerox hardcopy $6.58.

Over the past 2 decades the usefulness of the computer in science and education has been demonstrated by the rapid growth of applications. Striking advances have been made in data analysis and research through its use; however, in the direct application of computers to the instructional process, obstacles still exist between promise and fulfillment. This study seeks to identify those obstacles that have hindered the development and acceptance of computer use in instruction, and to suggest means for overcoming them. The Delphi Technique was used to obtain and analyze the judgment of educational practitioners, theoreticians, hardware and software specialists, and evaluators on (a) major impediments to wider use of computers in instruction, and (b) actions that might increase acceptance and use of computer-based instructional materials.

See also: Justifying CAI in Mainline Instruction.... page 6.

RECENT PUBLICATIONS

These publications are so new to the national ERIC system that they have not yet been assigned ED numbers necessary for ordering. To obtain the ED number, you may write the Stanford Clearinghouse, giving the EM number listed here. As soon as the ED numbers are assigned, they will be sent to you. The Clearinghouse address is:

The ERIC Clearinghouse on Media and Technology
Stanford Center for Research and Development in Teaching
Stanford University
Stanford, California 94305

CAI Planning and Utilization

Layman's Guide to the Use of Computers (EM 010 581).

Association for Educational Data Systems, 1971, 65 pages. Available from the Association for Educational Data Systems, 1201 Sixteenth Street N.W., Washington, D.C. 20036 for $3. EDRS price microfiche 65c.

In this introductory pamphlet, computers are defined, and the main components of a computer system (input, storage or memory, control, arithmetic logic, and output), the language of the computer and use of computers in education are discussed. The latter section considers computer science, computer-assisted instruction, programed instruction, educational games, and use of computers in counseling. Examples of programs in each area are given. A glossary is provided. The style is nontechnical and the treatment is brief.

U.S. Office of Education Support of Computer Projects, 1965-1971 (EM 010 665).

Lawrence P. Grayson and Janet B. Robbins, Office of Education, Washington, D.C., 1972, 286 pages. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 as Stock No. 1780-0823 for $2.50. EDRS price microfiche 65c, Xerox hardcopy $9.87.

Because of the potential of computers for improving education, the need for educating people about computers, and the major role that the U.S. Office of Education (USOE) has had in fostering the application of computers in education, it is important that a record be made of USOE's support of computer and computer-related projects. This report attempts to provide such a record: it considers the growth of computers in education, summarizes USOE support, and describes categories and legislative authority for support. A summary of project information by subject category is followed by a list of project abstracts organized by legislative act. The abstracts are listed under the appropriate act, with information about their sources and support. Regional Educational Laboratories, Research and Development Centers, and ERIC are also described.

The Emerging Technology. Instructional Uses of the Computer in Higher Education.

Roger E. Levien, Carnegie Commission on Higher Education, Berkeley, California, and the Rand Corporation, Santa Monica, California, 1972, 585 pages. Available from McGraw-Hill, 1221 Avenue of the Americas, New York, New York 10020 for $12.50. Not available from EDRS.

By presenting a comprehensive non-technical review of how computers operate, how extensively and effectively they are used, and what they cost, this book provides the lay person substantial information concerning computers in higher education. The major trends in computer development, past and future; the role of the computer in the administrative, research, and instruction areas of higher education; and the principal methods of providing computer service are discussed. The instructional aspect is reviewed in greater detail, dividing the analysis into three areas: the quantitative spread of computers in the nation's campuses; the technological range of machines and programs; and the state of the art in computer-assisted instruction. Future prospects for computers are examined, particularly cost-effectiveness analyses of not only economics and technology but also of institutions and attitudes.

Case Studies: Secondary Education

Developing Specifications for a Low-Cost Computer System for Secondary Schools. PREP Report Number 38 (EM 010 837).

George Kleiner, Stevens Institute of Technology, Hoboken, New Jersey, 1972, 71 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

More and more secondary schools are becoming interested in introducing their students to computers and computer concepts. A central problem for such schools, however, is obtaining reliable computer service with capacity for all the students who are interested, but at a cost the school can afford. Although many schools use commercial or small-scale time-sharing services, providing computer services to more than a few students becomes very expensive. Accordingly, various types of minicomputer systems are discussed in relation to the needs and capabilities of the schools. While a wide range of features are considered, special attention is paid to the peripheral equipment whose cost and reliability is so crucial to secondary school computer systems.

Cost-Effectiveness Studies

Markets and Models for Large-Scale Courseware Development (EM 010 725).

C. Victor Bunderson, Computer-Assisted Instruction Lab, Texas University, Austin, 1971, 16 pages, paper presented at the EASCON Meeting in Washington, D.C., October 6-8, 1971. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Computer-assisted instruction (CAI) is not making an important, visible impact on the educational system of this country. Though its instructional value has been proven time after time, the high cost of the hardware and the lack of quality courseware is preventing CAI from becoming a market success. In order for CAI to reach its market potential it must find a new educational target market. The junior colleges represent the best market for CAI because of their increasing enrollments and their intermediate position between the generally recalcitrant school districts and the graduate oriented universities. The high cost of hardware is being solved and all that really remains is for the CAI industry to meet the high-volume instruction requirements of the courseware. The production and dissemination of courseware will require a new design and development technology with high quality standards. The author discusses the entire subject of marketing CAI in depth.

Research Trends: Interactions Between Student Characteristics and Varieties of CAI

Studies of Instructional Technology Relating to Computer-Assisted Instruction. Final Report (EM 010 664).

Robert Glaser, Learning Research and Development Center, Pittsburgh University, 1972, 40 pages. EDRS price microfiche 65c, Xerox hardcopy $3.29.

A project was undertaken to carry out experimental and methodological investigations on learning phenomena and psychometric methods relevant to instructional technology and computer-assisted instruction. The project's accomplishments are presented in this report, along with a listing of reports and products produced. The work of the project is reported in terms of five areas of effort: 1) adaptation of instructional environments to the learning characteristics of the individual trainee; 2) computer testing, computer algorithms, and languages for experimental instructional systems; 3) exploration of techniques for learner manipulation of subject matter; 4) the development of concepts and techniques for the analysis of subject-matter structures; and 5) annual conferences on developments in learning relevant to instruction and development.

Learner-Controlled Computer-Assisted Instruction (EM 101 723).

Wilson A. Judd, Computer-Assisted Instruction Lab, Texas University, Austin, 1972, 21 pages, paper presented at the International School on Computer in Education in Pugnochiuso, Italy July 3-21, 1972. EDRS price microfiche 65c, Xerox hardcopy $3.29.

Research on which aspects of the instructional process are most appropriately placed under learner control is reviewed. The review covers representative experiments from the 1960's in brief and experiments at the University of Texas from 1970 to 1973 in more detail. Although it appears that learner control can help in mainline computer-assisted instruction (CAI), the characteristics of its role have not yet been well defined. The research in general has been inconclusive. Further research should focus on individual differences in learner control. Few studies found the expected conclusion that learner control improves student attitudes. However, one study found that learner-control students have lower scores on a state anxiety scale. Research should determine the conditions under which learner control would reduce student anxiety. Finally, it should be realized that learner control is not as simple an instructional treatment as was first imagined. Well controlled laboratory tests appear better than extensive instructional sequences as a way to study the conditions under which learner control is appropriate in CAI.

A Study of the Effectiveness of a Computer When Used as a Teaching and Learning Tool in High School Mathematics.

Franklin Delano Ronan, School of Education, Michigan University, Ann Arbor, 1971, 212 pages, thesis submitted to the School of Education of Michigan University. Available from University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48105 ($4 in microfilm, $10 in Xerox hardcopy). Not available from EDRS.

Suspecting that computer-assisted mathematics instruction helps students attain a higher level of achievement than normal instruction, the author conducted an experiment in two algebra-trigonometry classes. Fifty-one "middle ability" students were divided into two groups. The computer group used the computer both as a computational and teaching tool and as an experimental tool. The experiment revealed that the computer group had significantly higher achievement levels in: the treatment of exponential functions, logarithms, and trigonometric identities and formulas; the understanding of mathematical concepts and skills; and logic and reasoning ability. However, there was no significant difference between the groups in problem-solving ability or in the application of mathematical concepts.

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